

WHAT IS CLAIMED IS:

1. A semiconductor device comprising:
a substrate of semiconductor material,
said substrate having a well formed therein;
at least three substantially spiral
5 inductors formed within said well, said inductors being
arranged in said well such that each of said inductors
is inductively coupled to at least one other of said
inductors; and
a respective pair of input/output
10 terminals for each of said inductors.
2. The semiconductor device of claim 1
wherein:
each of said inductors has a center; and
said centers are substantially aligned
5 along an axis.
3. The semiconductor device of claim 2
wherein:
said first inductor has a first number
of turns;
5 said second inductor has a second number
of turns; and
said third inductor has a third number
of turns.
4. The semiconductor device of claim 3
wherein said first, second and third numbers are equal.
5. The semiconductor device of claim 4
wherein:

said semiconductor device has a major surface defining a plane; and

5 said well is formed in said major surface.

6. The semiconductor device of claim 5 wherein said well comprises:

 a bottom surface substantially parallel to said plane; and

5 a side wall substantially perpendicular to said plane.

7. The semiconductor device of claim 5 wherein said well comprises:

 a bottom surface substantially parallel to said plane; and

5 a side wall at an oblique angle relative to said plane.

8. The semiconductor device of claim 7 wherein said side wall is at an angle of about 54.74° relative to said plane.

9. The semiconductor device of claim 3 wherein:

 said semiconductor device has a major surface defining a plane; and

5 said well is formed in said major surface.

10. The semiconductor device of claim 9 wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall substantially perpendicular
to said plane.

11. The semiconductor device of claim 9
wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall at an oblique angle relative
to said plane.

12. The semiconductor device of claim 11
wherein said side wall is at an angle of about 54.74°
relative to said plane.

13. The semiconductor device of claim 2
wherein:

said semiconductor device has a major
surface defining a plane; and

5 said well is formed in said major
surface.

14. The semiconductor device of claim 13
wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall substantially perpendicular
to said plane.

15. The semiconductor device of claim 13
wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall at an oblique angle relative
to said plane.

16. The semiconductor device of claim 15
wherein said side wall is at an angle of about 54.74°
relative to said plane.

17. A coupled inductor structure having a
high quality factor, said structure comprising:

a substrate of semiconductor material,
said substrate having a well formed therein;

5 at least three substantially spiral
inductors formed within said well, said inductors being
arranged in said well such that each of said inductors
is inductively coupled to at least one other of said
inductors; and

10 a respective pair of input/output
terminals for each of said inductors.

18. The coupled inductor structure of
claim 17 wherein:

each of said inductors has a center; and
said centers are substantially aligned

5 along an axis.

19. The coupled inductor structure of
claim 18 wherein:

said first inductor has a first number
of turns;

5 said second inductor has a second number
of turns; and
 said third inductor has a third number
of turns.

20. The coupled inductor structure of
claim 19 wherein said first, second and third numbers
are equal.

21. The coupled inductor structure of
claim 20 wherein:

 said semiconductor device has a major
surface defining a plane; and
5 said well is formed in said major
surface.

22. The coupled inductor structure of
claim 21 wherein said well comprises:

 a bottom surface substantially parallel
to said plane; and
5 a side wall substantially perpendicular
to said plane.

23. The coupled inductor structure of
claim 21 wherein said well comprises:

 a bottom surface substantially parallel
to said plane; and
5 a side wall at an oblique angle relative
to said plane.

24. The coupled inductor structure of claim 23 wherein said side wall is at an angle of about 54.74° relative to said plane.

25. The coupled inductor structure of claim 18 wherein:

said semiconductor device has a major surface defining a plane; and

5 said well is formed in said major surface.

26. The coupled inductor structure of claim 25 wherein said well comprises:

a bottom surface substantially parallel to said plane; and

5 a side wall substantially perpendicular to said plane.

27. The coupled inductor structure of claim 25 wherein said well comprises:

a bottom surface substantially parallel to said plane; and

5 a side wall at an oblique angle relative to said plane.

28. The coupled inductor structure of claim 27 wherein said side wall is at an angle of about 54.74° relative to said plane.

29. The coupled inductor structure of claim 17 wherein:

said semiconductor device has a major surface defining a plane; and

5 said well is formed in said major surface.

30. The coupled inductor structure of claim 29 wherein said well comprises:

a bottom surface substantially parallel to said plane; and

5 a side wall substantially perpendicular to said plane.

31. The coupled inductor structure of claim 29 wherein said well comprises:

a bottom surface substantially parallel to said plane; and

5 a side wall at an oblique angle relative to said plane.

32. The coupled inductor structure of claim 31 wherein said side wall is at an angle of about 54.74° relative to said plane.

33. A signal splitting and combining circuit comprising:

a substrate of semiconductor material, said substrate having a well formed therein;

5 at least three substantially spiral inductors formed within said well, said inductors being arranged in said well such that each of said inductors is inductively coupled to at least one other of said

inductors, a third one of said inductors being coupled
10 between first and second ones of said inductors; and
a respective pair of input/output
terminals for each of said inductors; wherein:

when respective first and second signals
are input to each of first and second ones of said
15 pairs of input/output terminals, a sum of multiples of
said first and second signals is output on a third one
of said pairs of input/output terminals; and

when an input signal is input on said
third one of said pairs of input/output terminals,
20 respective first and second output signals are output
on respective ones of said first and second pairs of
input/output terminals, said input signal being a sum
of multiples of said first and second output signals.

34. The signal splitting and combining
circuit of claim 33 wherein:

each of said inductors has a center; and
said centers are substantially aligned
5 along an axis.

35. The signal splitting and combining
circuit of claim 34 wherein:

said first inductor has a first number
of turns;
5 said second inductor has a second number
of turns; and
said third inductor has a third number
of turns; wherein:

when said respective first and second
10 signals are input to each of said first and second ones

of said pairs of input/output terminals, said sum of multiples of said first and second signals is a sum of (a) a product of said first signal and a ratio of said third number of turns to said first number of turns, and (b) a product of said second signal and a ratio of said third number of turns to said second number of turns; and

when said input signal is input on said third one of said pairs of input/output terminals, said input signal is a sum of (a) a product of said respective first output signal and a ratio of said first number of turns to said third number of turns, and (b) a product of said respective second output signal and a ratio of said second number of turns to said third number of turns.

36. The signal splitting and combining circuit of claim 35 wherein said first, second and third numbers are equal; wherein each of said multiples is one.

37. The signal splitting and combining circuit of claim 36 wherein:

said semiconductor substrate has a major surface defining a plane; and

said well is formed in said major surface.

38. The signal splitting and combining circuit of claim 37 wherein said well comprises:

a bottom surface substantially parallel to said plane; and

5 a side wall substantially perpendicular
to said plane.

39. The signal splitting and combining
circuit of claim 37 wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall at an oblique angle relative
to said plane.

40. The signal splitting and combining
circuit of claim 39 wherein said side wall is at an
angle of about 54.74° relative to said plane.

41. The signal splitting and combining
circuit of claim 35 wherein:

said semiconductor substrate has a major
surface defining a plane; and

5 said well is formed in said major
surface.

42. The signal splitting and combining
circuit of claim 41 wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall substantially perpendicular
to said plane.

43. The signal splitting and combining
circuit of claim 41 wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall at an oblique angle relative
to said plane.

44. The signal splitting and combining
circuit of claim 43 wherein said side wall is at an
angle of about 54.74° relative to said plane.

45. The signal splitting and combining
circuit of claim 34 wherein:

said semiconductor substrate has a major
surface defining a plane; and

5 said well is formed in said major
surface.

46. The signal splitting and combining
circuit of claim 45 wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall substantially perpendicular
to said plane.

47. The signal splitting and combining
circuit of claim 45 wherein said well comprises:

a bottom surface substantially parallel
to said plane; and

5 a side wall at an oblique angle relative
to said plane.

48. The signal splitting and combining
circuit of claim 47 wherein said side wall is at an
angle of about 54.74° relative to said plane.

49. A method of forming a coupled inductor structure in a semiconductor substrate having a surface, said method comprising:

forming a well in said surface of said
5 substrate, said well having a bottom and a side wall;
depositing a first insulating layer on
said bottom of said well;

depositing a first lead-in conductor
over said first insulating layer;
10 depositing a second insulating layer
over said first lead-in conductor;

depositing a first spiral inductor over
said second insulating layer in contact with said first
lead-in conductor;

15 forming a first termination wire
conducting between said first spiral inductor and said
surface;

depositing a third insulating layer over
said first spiral inductor;

20 depositing a second lead-in conductor
over said third insulating layer;

depositing a fourth insulating layer
over said second lead-in conductor;

depositing a second spiral inductor over
25 said fourth insulating layer in contact with said
second lead-in conductor;

forming a second termination wire
conducting between said second spiral inductor and said
surface;

30 depositing a fifth insulating layer over
said second spiral inductor;

depositing a third lead-in conductor
over said fifth insulating layer;

depositing a sixth insulating layer over
35 said third lead-in conductor;

depositing a third spiral inductor over
said sixth insulating layer in contact with said third
lead-in conductor;

forming a third termination wire
40 conducting between said third spiral inductor and said
surface;

depositing a seventh insulating layer
over said third spiral inductor.

50. The method of claim 49 wherein said
forming said well comprises forming said well with said
side wall substantially perpendicular to said surface.

51. The method of claim 49 wherein said
forming said well comprises forming said well with said
side wall at an oblique angle relative to said surface.

52. The method of claim 51 wherein said
oblique angle is about 54.74° .

53. The method of claim 49 wherein said
depositing of any of said lead-in conductors comprises
electroplating.

54. The method of claim 53 wherein said
depositing of any of said spiral inductors comprises
electroplating.

55. The method of claim 54 wherein said forming of any one said termination wires comprises electroplating.

56. The method of claim 49 wherein said depositing of any of said spiral inductors comprises electroplating.

57. The method of claim 56 wherein said forming of any one said termination wires comprises electroplating.

58. The method of claim 49 wherein said forming of any one said termination wires comprises electroplating.